LAKE SUPERIOR OUTFLOW

1860 - 1968

BY
THE COORDINATING COMMITTEE
ON
GREAT LAKES BASIC HYDRAULIC AND HYDROLOGIC DATA

JUNE 1970

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INTRODUCTION

1. Requirement for internationally coordinated hydraulic and hydrologic data. The Great Lakes-St. Lawrence River system extends southerly and easterly from the headwaters of tributary streams in northern Minnesota and western Ontario some 2,000 miles to the Gulf of St. Lawrence in the Atlantic Ocean. The system drains a great interior basin of more than 295,000 square miles to the outlet of Lake Ontario, reaches almost half way across the North American continent, and borders upon eight states of the United States and two provinces of Canada. This vast series of lakes and rivers is shared by the United States and Canada. The joint use of these waters poses numerous international problems in the solution of which the two countries need coordinated basic data.

2. Prior to 1953, data pertaining to the hydraulic and hydrologic factors of the Great Lakes and St. Lawrence River were collected and compiled independently by the responsible federal agencies in Canada and the United States, with only superficial and informal correlation of some of the data. As a consequence, the data in many instances were developed on different bases and datum planes and were divergent in many respects. This situation resulted in a large volume of study and evaluation by each country of the data used by the other in the solutions of international problems.

3. Establishment of international study. The quantity and scope of the international problems were greatly increased by the advent of extremely high lake levels in 1952 and by the imminent power and navigation development in the St. Lawrence River System. Recognizing that continued independent development of the basic data was illogical under the circumstances and that early agreement upon the hydraulic and hydrologic factors was of paramount importance, the Corps of Engineers, United States Army, and the Departments of Transport, Mines and Technical Surveys, and Resources and Development, Canada, opened negotiations early in 1953 for the purpose of establishing a basis for development and acceptance by both countries of identical data. The negotiations culminated in a meeting of representatives of the interested agencies at Ottawa on 7 May 1953.

4. At the meeting, the Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data was formed to study the problem and to establish a basis of procedure. This Committee was established advisory to the agencies of the United States and Canada which are charged with the responsibility for collecting and compiling the Great Lakes hydraulic and hydrologic data. The Committee was constituted as follows:

Canada	United States
T. M. Patterson, Water Resources Division, Department of Resources and Development, Chairman	Gail A. Hathaway, Office, Chief of Engineers, Department of the Army, Chairman
J. E. R. Ross, Geodetic Survey of Canada, Department of Mines and Technical Surveys	Edwin W. Nelson, Great Lakes Division, Corps of Engineers, U.S. Army
D. M. Ripley, Special Projects Branch, Department of Transport	W. T. Laidly, U.S. Lake Survey, Corps of Engineers, U.S. Army

The present membership of the Coordinating Committee is as follows:

Canada	United States
A. T. Prince, Inland Waters Branch Department of Energy, Mines and Resources	H. F. Lawhead, North Central Division Corps of Engineers, U. S. Army
D. M. Ripley, Marine Hydraulics Branch, Department of Transport	L. D. Kirshner, U. S. Lake Survey, Corps of Engineers, U. S. Army

5. Three working committees, designated the River Flow Subcommittee, the Vertical Control Subcommittee, and the Lake Levels Subcommittee, were formed to assist the Coordinating Committee in its work. Subsequently, a fourth committee, designated the Physical Data Subcommittee, was formed. These subcommittees were directed to conduct the required technical studies through collaboration of the appropriate agencies of the United States and Canada. The River Flow Subcommittee which conducted the portion of the work reported herein was initially constituted as follows:

Canada	United States
C. G. Cline, Water Resources Branch Department of Northern Affairs and National Resources	F. W. Townsend, U. S. Lake Survey Corps of Engineers, U. S. Army

During the course of this study Mr. F. I. Morton, Water Resources Branch, also served as a member of the Subcommittee. The present membership of the River Flow Subcommittee is as follows:

Canada	United States
D. F. Witherspoon, Inland Waters Branch, Department of Energy, Mines and Resources	I. M. Korkigian, U. S. Lake Survey Corps of Engineers, U. S. Army

6. Authority. The River Flow Subcommittee was instructed to study the available records of outflow from Lake Superior and the methods employed in their derivation. Since it was known that the quantities and methods

were different, the subcommittee was instructed further to develop a method of deriving the outflows based upon the foregoing studies and upon other appropriate studies and to derive outflows for the entire period of record suited to the quality of data available.

7. Purpose and scope. The purpose of this report is to document the Lake Superior outflow studies and to record the outflows which were derived for the period 1860-1968. The Coordinating Committee terminated its Lake Superior outflow studies with the year 1968 with the understanding that the responsible federal agencies of Canada and the United States would continue the derivation and coordination of the outflows subsequent to that year.

8. Acknowledgments. Engineers and facilities of the Inland Waters Branch, Department of Energy, Mines and Resources, and the U. S. Lake Survey, Corps of Engineers, U. S. Army, were employed throughout the study. Water level and diversion records, river flow measurements, assistance and advice were furnished by the International Lake Superior Board of Control; the Inland Waters Branch, Department of Energy, Mines and Resources; the Soo Area Office, Corps of Engineers, U. S. Army; the Great Lakes Power Company, Limited; the Edison Sault Electric Company; and the U. S. Lake Survey, Corps of Engineers, U. S. Army.

9. Adoption. At a meeting of the Coordinating Committee held in Niagara Falls, Canada on September 17, 1969 the Coordinating Committee agreed with the recommendation of the River Flow Subcommittee to adopt this report.

PHYSICAL CONDITIONS AND BASIC DATA

10. Natural outlet control of Lake Superior. The entire outflow from Lake Superior during the period of record discharged through the St. Marys River. The location map of the river is shown on Plate 1. The river flows out of the southeast corner of Lake Superior in a southeasterly direction to Lake Huron, a total distance of 61, 63, or 75 miles according to the route traversed. The fall between the lakes averages about 22 feet. A rock ledge at the head of the St. Marys River rapids is the natural control of the St. Marys River. Paragraphs 11 and 12 pertain to present day conditions in the river.

11. Upper St. Marys River. The river falls about 1/4 foot in the first 14 miles from Point Iroquois to the head of the U. S. navigation canal at Sault Ste. Marie, Michigan. In the next 1-1/2 miles the river drops about 20 feet through the rapids.

12. Lower St. Marys River. About 2-1/2 miles below the rapids the river divides into two channels, one passing to the north end, the other to the west of Sugar Island. The flow in the northerly channel continues into Lake George and thence north of St. Joseph Island into North Channel, Lake Huron. The flow west of Sugar Island passes around Neebish Island into Lake Munuscong past St. Joseph Island and into Lake Huron. The fall in the lower river averages about 2 feet.

13. Section suitable for the determination of rapids flows. The rock ledge at the St. Marys River rapids acts as a submerged weir controlling the flow of the rapids. This section at Sault Ste. Marie is suitable for determination of flow. Stage-discharge relationships for the Southwest Pier gauge located about a mile above the rapids are determinable from field measurements of the rapids flow. The location of the gauge is shown on

Plate 3. The flows computed at this section plus diversions around the rapids for navigation and power make up the total St. Marys River flow. Plates 2 and 3 show the many changes which affected the determination of the flows from 1860 to 1922.

14. Water level records available. Beginning November 1870, stages at the head of the rapids are available from the records of the Southwest Pier gauge. Before 1870, Southwest Pier stages are available for summer months in 1860-1861 and 1867-1869 periods.

15. Lake Superior stages are available from the records of the Marquette gauge for the entire period 1860-1968. These lake stages were used to derive flows when Southwest Pier stages were unavailable in the period before November 1870.

16. Flow measurements available for development of stage-discharge relationships. Numerous field measurements of flow in the river were available for this study. The measurements suitable for development of stage-discharge relationships for rapids flow were as follows:

MEASURED DATA

YEAR	NUMBER OF MEASUREMENTS	HYDRAULIC SECTION
1895-1896	14	Bridge
1896	54	Sprys Dock
1899	63	Sprys Dock
1901	20	Bridge
1901	44	Bridge
1902	146	Bridge
1905	60	Brewery
1909	30	Bridge
1927-1929	109	Gates
1930	14	Gates

The locations of the hydraulic sections at which these measurements were made are shown on Plates 1, 2 and 3. Additional measurements were made

in 1935 and 1965. The 1965 measurements are not suitable for development of a stage-discharge relationship or for indicating inaccuracies in the present rating.

17. Diversion through Navigation Canals. The first ship canal in the St. Marys River was constructed on the south side of the rapids in 1855 by the State of Michigan. The United States government in 1871 started enlargement of the canal, which officially became federal property in 1881. Improvements of the U. S. navigation canal continued until September 1919 when there were four locks in operation. In September 1895 the lock in the Canadian navigation canal on the north side of the rapids was put into operation. No data are available to determine the flow in the U. S. canal before 1887, but subsequent data indicates that the flow during the navigation season was probably less than 200 cubic feet per second. The sources of the monthly flows through the navigation canals used in this report were the 1911 report of Noble and Woodard entitled, " Report on the Regulation of Lake Superior to Meet the Requirements of the United States War Department" ; the 1931 report of Horace M. Edmands entitled, " Report on Discharge of St. Marys River" ; and tables prepared each month by the Lake Superior Board of Control entitled, " Continuation of Tables in Appendix IV, Noble and Woodard's Report on Lake Superior Regulation". Changes in channel configuration for the navigation improvements are shown on Plates 2 and 3. Table 4 summarizes the diversions made for navigation.

18. Diversion through Power Canals. The first utilization of the St. Marys River rapids for the production of power was in 1822-1823 when a raceway and sawmill were built by the United States Army. In 1887

construction of a power canal through Sault Ste. Marie, Michigan, was started by the St. Marys Falls Water Power Company, which shortly thereafter abandoned the project. In 1902 the Michigan Lake Superior Power Company completed the canal now known as the Edison Sault Electric Company Canal. Construction of two other power canals was started in 1888; one by the Edison Sault Light and Power Company through Chandler-Dunbar Power Canal on the south side of the rapids, and the other by the Lake Superior Power Company on the north side of the rapids in Canada. By 1893 water in the Chandler-Dunbar Power Canal, now known as the U. S. Power Canal, was being used by the power plant on the south side of the rapids. In November 1895, the Lake Superior Power Company, now the Great Lakes Power Company, started to use the Canadian Power Canal. Changes in the channel configuration for power are shown in Plates 2 and 3. Diversions for power are summarized in Table 5.

19. The sources of the monthly flows in the power canals used in this report are the same as for the flows in the navigation canals mentioned above: the Noble and Woodard 1911 Report, the Edmands 1931 Report, and the Lake Superior Board of Control monthly tables beginning in 1931. The flows in the Chandler-Dunbar Power Canal tabulated in the Noble and Woodard Report were adjusted to reflect field observations of leakage from the canal made in 1895, 1901 and 1909 by U. S. Lake Survey. The tabulated monthly flows in the canal were reduced by the following amounts:

PERIOD	REDUCTION IN CFS	PERIOD	REDUCTION IN CFS
Jan. 1893-Dec. 1896	300	Sept. 1906-May 1907	300
Jan. 1897-Dec. 1897	200	June 1907-June 1908	400
Jan. 1898-Dec. 1898	100	July 1908-Feb. 1909	500
Jan. 1899-Nov. 1902	0	Mar. 1909-Apr. 1910	800
Dec. 1902-Sept.1904	100	May 1910-Dec. 1910	700
Oct. 1904-Aug. 1906	200		

BASIC PRINCIPLES ADOPTED

20. From consideration of the physical conditions of the St. Marys River and the basic data available, it was concluded that the basic principles for determining the Lake Superior outflows should be founded upon derivation of the flows through the St. Marys River rapids. Due to the limited extent of the drainage area adjacent to the river between Point Aux Pins and the rapids, and to the small amounts of local inflow contributed by these areas, the river flows at Sault Ste. Marie are considered to be equal to the Lake Superior outflows. In the establishment of the basic principles, it was necessary to consider three factors affecting the stage-discharge relationships for rapids flow: weed and ice retardation, river regimen changes, and diversions past the rapids for navigation and power.

21. Effects of ice and weed retardation on stage-discharge relationships. The stage-discharge relationships at Southwest Pier are considered to be unaffected by the presence of ice and weeds in the relatively short reach from the gauge to the head of the rapids. For the 1860-1870 period, an average winter flow retardation due to ice of 4,000 cfs was applied to the January through April flows from the Marquette stage-discharge relationship. The 4,000 cfs retardation is the average difference between winter discharges from recorded Marquette and Southwest Pier stages in the 1871-1887 period and the appropriate stage-discharge relationships. Thus the retardation used includes the effects of such factors as slope between Marquette and the rapids as well as the effects of ice. The May through December relationship between Marquette and the discharge, computed from the Southwest Pier equation, contains any weed effect that occurs.

22. Effects or river regimen changes on stage-discharge relationships. The 1931 Report by Edmands mentioned above reports three major changes in regimen of the rapids section of the river in the period before 1931: construction of International Railroad Bridge at Sault Ste. Marie in 1887; construction of the power canal along the south side of the rapids in 1892; and construction of the compensating works at the upper end of the rapids during the 1901-1921 period. By obstructing the flow, these changes in regimen affected the Southwest Pier stage-discharge relationship. These changes are shown on Plates 2 and 3. Since 1930 channel improvements and fills have been made in the rapids section, but the effects of these changes of regimen on the stage-discharge relationships for the compensating gates are considered to be minor and counterbalancing.

23. Effects of diversions from the river on stage-discharge relationships. Diversion from the river above the U. S. Navigation Canal into Edison Sault Electric Company Canal does not affect the Southwest Pier stage-discharge relationship. The diversions into the U. S. and Canadian navigation and power canals are taken from the river below the gauge and affect the stage-discharge relationship by increasing the outflow capacity.

24. Principles adopted. Based upon consideration of all of the above factors, the principles adopted for the Lake Superior outflow determination were as follows:

a. To accept side channel flows as described in paragraphs 17 through 19.

b. Flow at the rapids section of the river as computed from Southwest Pier stage-discharge relationships would be used to determine

St. Marys River monthly flows during entire 1860-1968 period. The Marquette stage-discharge relationship would be used for the months in the 1860-1870 period for which Southwest Pier stages are not available.

c. It was concluded that insufficient data are available to determine daily mean outflows of the past with meaningful precision, and that a new rating of the compensating works will be required before daily outflows can be determined in the future.

d. Monthly mean Lake Superior outflows would be derived for the entire period 1860-1968.

DEVELOPMENT OF STAGE-DISCHARGE RELATIONSHIPS

25. Marquette stage-discharge relationship. Because of missing Southwest Pier water levels, a Marquette stage-discharge relationship was derived from the period when Southwest Pier levels were available during the 1872-1887 period. This Marquette relationship was used when the Southwest Pier levels were missing during the January 1860-October 1870 period. The equation of this stage-discharge relationship is:

$$Q = 4901 \text{ (Marquette - } 593.71)^{1.5}$$

where Q is the discharge in cubic feet per second and Marquette is the stage in feet, IGLD (1955). Plate 4 shows this relationship and the flows and stages on which it is based.

26. Southwest Pier stage-discharge relationships. The stage-discharge relationship for the period before construction of the International Railroad Bridge was derived from the relationship developed for the period after construction by adjusting for effects of the bridge piers and closure of small channels between the islands on north side of the river. The

equation of this relationship is:

$$Q = 5516 \text{ (Southwest Pier - } 594.39)^{1.5}$$

It was concluded that this relationship was applicable for the period January 1860-September 1887. Plate 5 shows this Southwest Pier relationship and the adjustments used in its derivation.

27. The stage-discharge relationship for the period between construction of the bridge and construction of the Chandler-Dunbar forebay was derived from the relationship developed for period after forebay construction by adjusting for the effects of diverting the flow through the first two spans at south end of bridge. The reduction in rapids discharge capacity due to construction of the forebay was calculated as 8 per cent at stage 600 feet and 10 per cent at 601.5 feet. The equation of this relationship is:

$$Q = 4946 \text{ (Southwest Pier - } 594.32)^{1.5}$$

It was concluded that this relationship was applicable for the period July 1888-May 1892. This equation is also shown on Plate 5.

28. During the period between construction of the Chandler-Dunbar Power Canal and construction of the first four gates of the compensating works, field measurements of river flow were made in 1895, 1896, 1899 and 1901. A stage-discharge relationship for Southwest Pier was derived from these measurements grouped by stage. The equation of the relationship is:

$$Q = 4040 \text{ (Southwest Pier - } 593.80)^{1.5}$$

It was concluded that this relationship was applicable for the period January 1893-July 1901. Plate 6 shows this relationship and the measured data on which it is based.

29. During the period between construction of cofferdams for the first four gates and filling at Northwest Pier, field measurements of river flow were made in 1901, 1902 and 1905. A stage-discharge relationship for Southwest Pier was derived from these measurements grouped by stage. The equation for the relationship is:

$$Q = 3936 \text{ (Southwest Pier - } 594.39)^{1.5}$$

It was concluded that this relationship was applicable for the period November 1901-April 1909. Plate 7 shows this relationship and the measured data on which it is based.

30. During the period between filling at Northwest Pier and widening of U. S. Power Canal to divert the flow through two additional bridge spans, field measurements of river flow were made in September 1909. A stage-discharge relationship for Southwest Pier was derived from these measurements grouped by stage and paralleling the equation applicable for period before filling. The equation for this relationship is:

$$Q = 3936 \text{ (Southwest Pier - } 594.65)^{1.5}$$

It was concluded that this relationship was applicable for the period June 1909-January 1911. The relationship and the data on which it is based are also shown on Plate 7.

31. In the 1931 Edmands report twenty-five Southwest Pier stage-discharge relationships were derived for changes in rapids regimen made during the period between widening of U. S. Power Canal and completion of the compensating works in 1921. It was concluded that these relationships were applicable for the period 1 February 1911-12 August 1921 during the times shown in the report.

32. During the period after construction of the compensating works, field measurements of river flow were made in 1927, 1928, 1929 and 1930. Sixteen Southwest Pier stage-discharge relationships for standard gate opening of the 16 gates were derived from these measurements in the Edmands report. The relationships are shown in equation form on Table 2. It was concluded that these relationships were applicable for the period 13 August 1921 to date.

33. Summary of Southwest Pier equations. The stage-discharge equations for flow through the rapids during the 1860-1911 period, as adopted by the Committee are shown in Table 1. In using these equations to compute the monthly flows in the transition periods, the effects of the regimen changes on the flows, were proportionately increased over the period. These relationships and their applicable hydraulic conditions are summarized in Table 1. Southwest Pier stage in the equations is referred to International Great Lakes Datum (1955).

DERIVATION OF OUTFLOWS

34. General. The monthly Lake Superior outflow is derived from the addition of the flow through the rapids, the flow through the U. S. and Canada Navigation Canals, the Edison Sault Electric Company Canal, the U. S. Power Canal, and the Canadian Power Canal. The diversion flows are provided by the navigation and power entities in each country. The rapids flows are computed from the relationships shown in Table 1. The rating used since August 1921 for the rapids flows is that shown in Table 2. This rating is based on the 1935 measurements. Further measurements were made in 1965 but were not of sufficient detail to establish a new rating of the

compensating works. The flow through the rapids and the flows in the navigation and power canals are shown on Tables 3 through 5.

35. Rapids flows, 1860-1870. In this period, monthly mean flows through the rapids were derived from Lake Superior stages at Marquette. When available, Southwest Pier stages were used.

36. Rapids flows, 1871-1968. In this period, monthly mean flows through the rapids were derived from Southwest Pier stages.

RESULTS

37. The results of this Lake Superior outflows determination are shown on Table 6, the Mean Monthly Lake Superior Outflow 1860-1968.

COORDINATING COMMITTEE ON GREAT LAKES
BASIC HYDRAULIC AND HYDROLOGIC DATA

LAKE SUPERIOR OUTFLOW 1860-1968

TABLE 1

ST. MARYS RIVER DISCHARGE EQUATIONS AND
HYDRAULIC CONDITIONS BEFORE 1923

No.	Date	Hydraulic Section			Discharge Equation
		Bridge Spans	Gates Open	Structures in Section	
1	Jan. 1860-Sept. 1887	0		0	$Q = 5516\ (SWP-594.39)^{1.5}$
2	Jan. 1860-Oct. 1870 **				$Q = 4901\ (Marquette-593.71)^{1.5}$
3	Oct. 1887-June 1888	0-10		Construction of Bridge Piers and Approaches	Transition 2 to 4
4	July 1888-May 1892	10(1-10)		Bridge in Place	$Q = 4946\ (SWP-594.32)^{1.5}$
5	June 1892-Dec. 1892	10 to 8		Spans 1 and 2 diked off	Transition 4 to 6
6*	Jan. 1893-July 1901	8(3-10)		All streams on Canadian side closed	$Q = 4040\ (SWP-593.80)^{1.5}$
7*	Aug. 1901-Oct. 1901	8 to 6	0	Construction of compensating works started. Coffer-dams closed spans 8 and 9.	Transition 6 to 8
8*	Nov. 1901-Apr. 1909	6(3-8)	0		$Q = 3936\ (SWP-594.39)^{1.5}$
9	May 1909	6	0		Transition 8 to 10

** S.W.P. levels not available

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No.	Date	Hydraulic Section			Discharge Equation
		Bridge Spans	Gates Open	Structures in Section	
10	June 1909-Jan. 1911	6 to 4	0	Closing spans 3 and 4	$Q = 3936\ (SWP-594.65)^{1.5}$
11*	Feb. 1911-Sept. 1914	Approx. 4	0	Cofferdam removed from span 9	$Q = 2787\ (SWP-593.74)^{1.5}$
12	Oct. 1914-Nov. 1914	4(5-8)	4(1-4)		$Q = 3166\ (SWP-593.78)^{1.5}$
13*	Dec. 1914-Sept. 1915	2(7-8)	4(1-4)	Breakwater in front of spans 5-6	$Q = 2338\ (SWP-593.60)^{1.5}$
14*	Oct. 1915-May 1916	2(5,8)	7(1-4,14-16)	Span 5 partly obstructed	$Q = 2126\ (SWP-593.62)^{1.5}$
15	June 1916-15 Sept. 1916	2(5,8)	12(1-4,9-16)	Breakwater above span 5 removed	$Q = 2232\ (SWP-593.62)^{1.5}$
16*	16 Sept. 1916-20 June 1917	2(5,8)	12(1-4)(9-16)	Excavation complete above Gates 9-16	$Q = 2921\ (SWP-593.75)^{1.5}$
17	21 June 1917-3 Aug. 1917	2(5,8)	8(1-4)(13-16)	Part of span 5 obstructed by dike	$Q = 2600\ (SWP-593.71)^{1.5}$
18	4 Aug. 1917-12 Aug. 1917	2(5,8)	0		$Q = 1544\ (SWP-593.27)^{1.5}$
19	13 Aug. 1917	2(5,8)	2(3,4)		$Q = 2000\ (SWP-593.63)^{1.5}$

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TABLE 1

ST. MARYS RIVER DISCHARGE EQUATIONS AND
HYDRAULIC CONDITIONS BEFORE 1923

No.	Date	Hydraulic Section			Discharge Equation
		Bridge Spans	Gates Open	Structures in Section	
20	14 Aug. 1917-27 Nov. 1917	2(5,8)	4(1-4)		$Q = 2252\ (SWP-593.67)^{1.5}$
21	28 Nov. 1917-30 Nov. 1917	2(5,8)	0		Same as No. 18
22	1 Dec. 1917-8 May 1918	$1\frac{3}{4}$ (5,$\frac{3}{4}$ of 8)	0	Breakwater partly obstructing span 8. Enlargement of Bridge Piers underway in 1918.	$Q = 1273\ (SWP-593.02)^{1.5}$
23	9 May 1918	$1\frac{3}{4}$ (5,$\frac{3}{4}$ of 8)	1(16)		$Q = 1509\ (SWP-593.28)^{1.5}$
24	10 May 1918	$1\frac{3}{4}$ (5,$\frac{3}{4}$ of 8)	0		Same as No. 22
25	11 May 1918	$1\frac{3}{4}$ (5,$\frac{3}{4}$ of 8)	2(15,16)		$Q = 1734\ (SWP-593.51)^{1.5}$
26	12 May 1918-24 June 1918	$1\frac{3}{4}$ (5,$\frac{3}{4}$ of 8)	1(16)		Same as No. 23
27	25 June 1918-1 July 1918	$1\frac{3}{4}$ (5,$\frac{3}{4}$ of 8)	0		Same as No. 22
28	2 July 1918	$1\frac{3}{4}$ (5,$\frac{3}{4}$ of 8)	2(10,11)		Same as No. 25
29	3 July 1918	$1\frac{3}{4}$ (5,$\frac{3}{4}$ of 8)	0		Same as No. 22
30	4 July 1918-6 July 1918	$1\frac{3}{4}$ (5,$\frac{3}{4}$ of 8)	2(12,13)		Same as No. 25

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TABLE 1

ST. MARYS RIVER DISCHARGE EQUATIONS AND HYDRAULIC CONDITIONS BEFORE 1923

No.	Date	Hydraulic Section			Discharge Equation
		Bridge Spans	Gates Open	Structures in Section	
31	7 July 1918-15 Aug. 1918	1(5)	0	Cofferdam obstructing span 8 for construction of Gates 5-8.	$Q = 602.1 (SWP-593.18)^{1.5}$
32	16 Aug. 1918-20 Aug. 1918	1(5)	1(1)		$Q = 774.8 (SWP-592.90)^{1.5}$
33	21 Aug. 1918-12 Sept. 1918	1(5)	2(11,13)(12,14)(11,14)		$Q = 946.7 (SWP-592.87)^{1.5}$
34	13 Sept. 1918	1(5)	0		Same as No. 31
35	14 Sept. 1918-16 Sept. 1918	1(5)	4(11-14)		$Q = 1384 (SWP-593.29)^{1.5}$
36	17 Sept. 1918	1(5)	0		Same as No. 31
37	18 Sept. 1918-12 Nov. 1918	1(5)	4(11-14)		Same as No. 35
38	13 Nov. 1918-25 Nov. 1918	1(5)	2(11,14)		Same as No. 33
39	26 Nov. 1918-4 July 1919	1(5)	0		Same as No. 31
40	5 July 1919	1(5)	8(9-16)		$Q = 2037 (SWP-593.63)^{1.5}$
41	6 July 1919-3 Sept. 1919	1(5)	0		Same as No. 31
42	4 Sept. 1919-5 Sept. 1919	1(5)	4(11-14)		Same as No. 35

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TABLE 1

ST. MARYS RIVER DISCHARGE EQUATIONS AND
HYDRAULIC CONDITIONS BEFORE 1923

No.	Date	Hydraulic Section			Discharge Equation
		Bridge Spans	Gates Open	Structures in Section	
43	6 Sept. 1919-29 April 1920	1(5)	0		Same as No. 31
44	3 Apr. 1920-6 May 1920	1(5)	4(13-16)		Same as No. 35
45	7 May 1920-26 July 1920	1(5)	7(1-3,13-16)		$Q = 2054\ (SWP-593.81)^{1.5}$
46	27 July 1920-4 Aug. 1920	1(5)	11(1-3,9-16)		$Q = 2316\ (SWP-593.63)^{1.5}$
47	5 Aug. 1920-10 Aug. 1920	1(5)	12(1-4,9-16)		$Q = 2373\ (SWP-594.56)^{1.5}$
48	11 Aug. 1920-8 Sept. 1920	1(5)	16(1-16)		$Q = 2833\ (SWP-593.75)^{1.5}$
49	9 Sept. 1920-16 Sept. 1920	1(5)	8(1-8)		$Q = 2208\ (SWP-593.68)^{1.5}$
50	17 Sept. 1920-11 Oct. 1920	1(5)	4(1-4)		$Q = 1470\ (SWP-593.25)^{1.5}$
51	12 Oct. 1920-1 Aug. 1921	1(5)	0		Same as No. 31
52	2 Aug. 1921-9 Aug. 1921	1(5)	2(15,16)		Same as No. 33
53	10 Aug. 1921-12 Aug. 1921	1(5)	3(14-16)		$Q = 1162\ (SWP-593.07)^{1.5}$
54	13 Aug. 1921	1(5)	4(13-16)	Span 5 closed	$Q = 1384\ (SWP-593.29)^{1.5}$
55	14 Aug. 1921-Aug. 1922	0	Standard	Compensating Works completed.	See Table 2 for equation of standard gate openings
56	Aug. 1922-April 1933			Excavation downstream gates 9-16	

☆ Based on current meter data.
NOTE: SWP is level at Southwest Pier Gauge (ICLD 1955) datum.

COORDINATING COMMITTEE ON GREAT LAKES
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TABLE 2

ST. MARYS RIVER FLOWS
RAPIDS DISCHARGE EQUATIONS FOR STANDARD GATE OPENINGS

$$Q = a\ (S.W.P. - b)^{1.5}$$

Number of Gates Open	Gate Numbers	Equation Constants a	b
1	9	196.8	591.60
2	8-9	393.0	591.21
3	8-10	588.6	591.41
4	7-10	833.0	591.94
5	7-11	1077	592.42
6	6-11	1350	592.83
7	6-12	1618	593.22
8	5-12	1874	593.52
9	5-13	2022	593.62
10	4-13	2112	593.62
11	4-14	2213	593.65
12	3-14	2278	593.62
13	3-15	2364	593.62
14	2-15	2458	593.65
15	2-16	2538	593.65
16	1-16	2601	593.62

NOTE: Equations taken from Plate 30B, Edmands' report on Discharge of St. Marys River, 1931. Southwest Pier levels, S.W., are on IGLD (1955) datum.

COORDINATING COMMITTEE ON GREAT LAKES
BASIC HYDRAULIC AND HYDROLOGIC DATA

LAKE SUPERIOR OUTFLOW 1860-1968

TABLE 3

ST. MARYS RIVER RAPIDS DISCHARGE
IN HUNDREDS OF CUBIC FEET PER SECOND

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1860	661	655	711	728	821	862	876	874	864	868	829	760
1861	668	664	659	664	841	887	927	904	906	889	858	794
1862	735	653	630	622	737	760	768	807	816	823	779	740
1863	655	627	599	578	634	643	665	715	744	742	758	695
1864	608	585	565	548	648	660	678	704	708	678	625	644
1865	563	500	501	568	706	766	816	816	812	803	715	667
1866	545	477	508	590	665	717	751	775	766	779	758	656
1867	570	615	632	638	738	722	803	829	817	770	729	679
1868	609	513	601	673	675	702	751	761	774	723	742	742
1869	609	572	501	592	702	711	811	904	987	980	904	735
1870	653	613	615	632	697	846	883	884	914	884	862	815
1871	731	698	648	673	787	870	906	889	901	860	813	731
1872	688	671	619	619	791	827	908	978	991	959	929	833
1873	755	719	725	727	839	868	961	1015	1028	1002	954	906
1874	791	759	739	713	797	885	965	976	974	1002	954	931
1875	837	787	778	829	891	961	978	980	1041	1013	948	831
1876	825	815	765	770	923	1050	1153	1160	1169	1097	1030	927
1877	864	870	847	821	825	868	942	961	910	918	868	835
1878	971	739	719	717	770	823	845	837	784	803	784	741
1879	665	591	546	569	639	664	721	727	711	717	683	608
1880	573	566	550	553	690	839	891	864	897	852	856	801
1881	737	719	723	700	784	831	872	856	893	993	970	901
1882	795	751	727	727	799	819	889	912	897	876	870	811
1883	727	708	710	721	721	795	829	918	847	819	795	743
1884	723	686	669	637	708	727	770	780	795	811	817	778
1885	747	723	698	664	778	839	876	925	874	835	821	767
1886	700	669	669	665	745	778	811	841	813	817	784	731
1887	688	662	656	630	698	767	843	819	791	818	765	698
1888	662	596	600	592	693	845	871	869	854	850	812	747
1889	698	647	650	648	747	780	831	833	831	803	747	680

COORDINATING COMMITTEE ON GREAT LAKES
BASIC HYDRAULIC AND HYDROLOGIC DATA

LAKE SUPERIOR OUTFLOW 1860-1968

TABLE 3

ST. MARYS RIVER RAPIDS DISCHARGE
IN HUNDREDS OF CUBIC FEET PER SECOND

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1890	689	592	592	580	652	758	825	808	788	776	749	702
1891	581	600	575	605	668	659	678	682	669	680	661	626
1892	605	546	517	541	614	671	689	684	688	663	615	567
1893	537	508	510	545	615	697	727	742	721	712	702	631
1894	603	589	573	625	764	803	826	828	807	813	797	759
1895	720	697	666	663	704	766	805	808	836	856	771	751
1896	671	671	640	653	755	821	843	845	823	755	759	745
1897	707	660	662	683	739	797	835	860	833	797	780	701
1898	624	591	567	586	630	694	747	766	787	763	735	721
1899	646	624	607	606	743	817	850	875	906	850	831	823
1900	724	712	665	669	699	710	747	782	867	872	890	821
1901	747	699	665	682	724	743	810	811	760	750	712	654
1902	597	555	544	567	594	649	684	686	699	670	683	657
1903	589	554	543	577	636	698	718	734	737	762	743	673
1904	592	533	527	578	627	664	686	696	712	738	721	658
1905	614	554	522	580	622	649	703	723	760	759	723	690
1906	640	592	560	568	614	667	690	696	683	666	642	606
1907	560	533	520	541	568	627	657	680	712	718	678	630
1908	557	506	493	490	553	625	667	686	652	628	587	557
1909	505	473	460	455	484	508	541	563	558	548	537	548
1910	490	457	435	460	494	508	501	508	497	491	471	419
1911	377	331	314	316	343	384	423	474	475	478	458	445
1912	429	406	389	402	454	494	496	512	520	526	501	478
1913	430	406	382	407	460	487	517	532	533	560	547	540
1914	481	464	431	430	477	502	524	528	535	588	566	395
1915	363	347	342	328	358	380	415	422	424	412	425	407
1916	392	379	355	378	434	495	520	526	605	647	625	586
1917	508	482	466	484	494	499	478	405	432	426	394	244
1918	225	216	211	212	242	272	153	169	270	269	219	120
1919	117	111	106	111	118	122	134	127	135	121	124	120

COORDINATING COMMITTEE ON GREAT LAKES
BASIC HYDRAULIC AND HYDROLOGIC DATA

LAKE SUPERIOR OUTFLOW 1860-1968

TABLE 3

ST. MARYS RIVER RAPIDS DISCHARGE
IN HUNDREDS OF CUBIC FEET PER SECOND

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1920	111	106	104	119	336	372	408	517	381	187	122	115
1921	110	102	98	102	114	121	125	132	127	130	83	67
1922	50	36	34	36	80	42	44	55	53	49	52	66
1923	47	45	43	42	94	46	47	49	49	53	53	62
1924	64	51	50	68	51	51	52	52	53	53	53	52
1925	50	49	49	50	44	26	26	66	203	202	190	139
1926	63	56	55	66	53	37	37	75	171	194	251	254
1927	191	201	191	203	223	241	256	267	260	265	291	244
1928	230	214	205	236	251	214	213	335	496	545	548	493
1929	196	52	84	440	410	182	348	228	181	61	57	53
1930	42	49	49	48	85	126	286	418	292	74	53	52
1931	54	52	51	50	189	197	209	211	208	213	217	205
1932	56	54	36	103	206	246	241	238	391	365	352	229
1933	148	146	142	146	158	203	310	170	213	227	223	62
1934	57	56	54	55	59	198	403	457	365	230	292	418
1935	152	56	188	387	424	307	347	353	410	498	442	86
1936	56	54	54	55	252	274	275	267	242	166	160	58
1937	52	52	52	52	57	159	118	124	134	134	134	74
1938	64	62	61	65	337	547	548	545	530	495	474	62
1939	58	56	55	189	480	523	559	552	537	466	151	76
1940	55	50	25	25	26	26	26	26	26	26	26	26
1941	26	25	25	25	19	5	5	5	5	158	468	257
1942	245	92	9	326	92	233	354	212	191	82	5	5
1943	5	53	162	232	303	509	560	576	558	504	382	167
1944	100	13	13	13	13	13	232	417	512	544	416	249
1945	155	150	150	282	486	477	175	178	143	215	341	165
1946	163	150	148	358	443	178	182	155	173	172	177	172
1947	157	152	146	148	162	176	554	549	408	517	284	176
1948	157	147	142	150	117	65	28	22	16	16	16	16
1949	16	16	16	27	63	66	69	180	274	144	124	74

COORDINATING COMMITTEE ON GREAT LAKES
BASIC HYDRAULIC AND HYDROLOGIC DATA

LAKE SUPERIOR OUTFLOW 1860-1968

TABLE 3

ST. MARYS RIVER RAPIDS DISCHARGE
IN HUNDREDS OF CUBIC FEET PER SECOND

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1950	64	62	61	62	69	432	584	597	583	581	555	522
1951	209	190	195	426	538	554	574	569	581	590	568	402
1952	205	196	187	197	436	156	42	522	526	493	432	128
1953	112	106	104	163	305	341	419	542	531	489	363	163
1954	106	102	100	100	116	122	404	505	478	313	114	49
1955	27	26	26	26	96	103	69	31	25	84	179	126
1956	106	102	96	128	37	27	28	62	65	63	34	28
1957	28	27	27	27	28	28	29	132	169	109	65	62
1958	58	57	55	55	57	58	36	29	29	48	56	54
1959	51	49	48	49	33	29	29	54	143	454	497	231
1960	97	58	56	58	111	462	494	410	378	263	119	53
1961	41	26	26	26	37	50	36	27	27	27	24	24
1962	23	23	23	23	23	24	24	24	24	56	54	32
1963	26	26	26	26	27	27	27	28	98	106	125	66
1964	50	49	46	45	52	58	161	320	389	421	467	242
1965	190	178	172	177	257	308	447	453	414	362	348	182
1966	108	104	102	145	112	116	288	275	367	208	108	69
1967	52	51	48	52	164	213	221	224	188	28	28	27
1968	27	26	26	27	27	28	331	538	543	572	552	380

COORDINATING COMMITTEE ON GREAT LAKES
BASIC HYDRAULIC AND HYDROLOGIC DATA

LAKE SUPERIOR OUTFLOW 1860-1968

TABLE 4

TOTAL DIVERSION FOR NAVIGATION
IN HUNDREDS OF CUBIC FEET PER SECOND

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1887	0	0	0	0	2	2	2	2	2	2	2	0
1888	0	0	0	0	2	2	2	2	2	2	2	0
1889	0	0	0	0	2	2	2	2	2	2	2	0
1890	0	0	0	0	2	2	2	2	2	2	2	0
1891	0	0	0	0	2	2	2	2	2	2	2	0
1892	0	0	0	0	3	3	3	3	3	3	3	0
1893	0	0	0	0	2	2	2	2	2	2	2	0
1894	0	0	0	0	3	3	3	3	3	3	3	0
1895	0	0	0	0	4	4	4	4	4	4	4	0
1896	0	0	0	0	7	7	7	7	7	7	7	0
1897	0	0	0	0	8	8	8	8	8	8	8	0
1898	0	0	0	0	8	8	8	8	8	8	8	0
1899	0	0	0	0	9	9	9	9	9	9	9	0
1900	0	0	0	0	8	8	8	8	8	8	8	0
1901	0	0	0	0	9	9	9	9	9	9	9	0
1902	0	0	0	0	10	10	10	10	10	10	10	0
1903	0	0	0	0	9	9	9	9	9	9	9	0
1904	0	0	0	0	8	8	8	8	8	8	8	0
1905	0	0	0	0	10	10	10	10	10	10	10	0
1906	0	0	0	0	10	10	10	10	10	10	10	0
1907	0	0	0	0	10	10	10	10	10	10	10	0
1908	0	0	0	0	9	9	9	9	9	9	9	0
1909	0	0	0	0	10	10	10	10	10	10	10	0
1910	0	0	0	0	10	10	10	10	10	10	10	0
1911	0	0	0	0	10	10	10	10	10	10	10	0
1912	0	0	0	0	11	11	11	11	11	11	11	0
1913	0	0	0	0	11	11	11	11	11	11	11	0
1914	0	0	0	0	10	10	10	10	10	10	10	0
1915	0	0	0	0	13	13	13	13	13	13	13	0
1916	0	0	0	0	14	14	30	33	33	33	24	0
1917	0	0	0	4	13	13	13	13	13	13	13	5
1918	0	0	0	4	12	13	13	13	13	13	10	4
1919	0	0	0	6	12	12	13	10	13	13	10	24

COORDINATING COMMITTEE ON GREAT LAKES
BASIC HYDRAULIC AND HYDROLOGIC DATA

LAKE SUPERIOR OUTFLOW 1860-1968

TABLE 4

TOTAL DIVERSION FOR NAVIGATION
IN HUNDREDS OF CUBIC FEET PER SECOND

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1920	21	21	26	8	12	14	15	15	14	14	11	10
1921	0	0	0	5	10	11	12	12	11	11	11	10
1922	0	0	0	2	9	13	15	16	14	13	13	4
1923	0	0	0	0	12	15	16	15	15	15	14	3
1924	0	0	0	3	14	15	14	13	14	14	10	3
1925	0	0	0	5	14	14	15	15	15	15	12	3
1926	0	0	0	1	13	16	16	16	16	16	12	3
1927	0	0	1	8	14	15	15	15	14	14	11	3
1928	0	0	0	1	12	15	15	15	17	16	13	5
1929	0	0	0	6	15	16	16	16	15	14	10	2
1930	0	0	0	1	13	15	15	15	14	13	10	2
1931	0	0	0	3	10	12	13	13	12	11	9	3
1932	1	0	0	2	7	9	9	9	9	9	8	2
1933	0	0	0	2	8	8	10	11	12	11	7	2
1934	1	1	2	2	11	12	12	12	11	10	7	3
1935	0	0	0	4	11	12	13	13	12	12	9	3
1936	0	0	0	4	12	14	14	14	14	14	11	2
1937	0	0	0	8	16	16	16	16	16	13	9	2
1938	0	0	0	3	8	9	11	11	10	11	9	3
1939	0	0	0	1	10	13	25	70	35	15	14	4
1940	0	0	0	4	14	15	16	17	16	16	13	3
1941	0	0	0	11	17	17	17	17	16	15	15	5
1942	1	0	2	13	15	16	16	16	15	15	14	4
1943	2	0	0	4	14	15	19	19	19	19	17	5
1944	0	0	2	10	16	17	17	17	17	16	12	3
1945	1	0	3	13	16	16	17	17	16	15	12	2
1946	0	0	0	6	10	13	16	16	15	16	14	3
1947	0	0	0	7	15	17	18	17	16	16	14	4
1948	0	0	0	10	16	16	17	17	16	16	15	4
1949	0	0	1	14	16	17	19	18	16	9	7	2

COORDINATING COMMITTEE ON GREAT LAKES
BASIC HYDRAULIC AND HYDROLOGIC DATA

LAKE SUPERIOR OUTFLOW 1860-1968

TABLE 4

TOTAL DIVERSION FOR NAVIGATION
IN HUNDREDS OF CUBIC FEET PER SECOND

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1950	0	0	0	3	14	17	17	17	16	16	13	4
1951	0	0	1	11	17	18	18	18	17	17	13	4
1952	0	0	0	11	17	12	11	18	18	18	16	4
1953	0	0	1	15	17	18	19	19	17	16	11	2
1954	0	0	0	5	14	15	16	15	14	12	9	3
1955	0	0	0	7	16	16	18	17	16	16	12	3
1956	0	0	0	11	16	17	11	14	16	16	13	4
1957	0	0	0	7	16	17	19	17	16	15	10	2
1958	0	0	0	5	11	14	16	16	14	14	10	2
1959	0	0	0	6	16	17	16	11	10	10	12	6
1960	0	0	0	9	16	17	17	16	14	13	8	3
1961	0	0	0	6	11	14	17	16	15	12	11	3
1962	0	0	0	5	12	14	15	14	13	12	9	3
1963	0	0	0	4	11	13	15	15	13	12	10	3
1964	0	0	0	8	12	13	15	15	13	12	11	3
1965	0	0	0	4	10	13	16	16	13	12	10	3
1966	0	0	0	9	13	14	16	15	14	12	11	4
1967	0	0	0	7	12	14	15	14	13	12	11	4
1968	0	0	0	9	12	13	16	14	13	11	9	4

COORDINATING COMMITTEE ON GREAT LAKES
BASIC HYDRAULIC AND HYDROLOGIC DATA

LAKE SUPERIOR OUTFLOW 1860-1968

TABLE 5

TOTAL DIVERSION FOR POWER
IN HUNDREDS OF CUBIC FEET PER SECOND

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1893	13	13	13	13	13	13	13	13	13	13	13	13
1894	13	13	13	13	13	13	13	13	13	13	13	13
1895	13	13	13	13	13	13	13	13	13	13	14	20
1896	28	30	25	32	22	18	24	22	29	35	40	29
1897	28	28	29	20	22	23	34	26	31	37	46	51
1898	50	43	41	45	52	54	44	42	27	38	49	56
1899	47	50	60	47	55	42	52	43	51	61	47	33
1900	67	62	67	60	60	66	67	66	49	59	42	24
1901	48	55	22	22	22	35	41	40	41	48	56	65
1902	66	63	30	43	49	34	44	55	65	64	58	36
1903	56	59	54	38	55	64	65	63	50	36	49	60
1904	124	144	149	125	123	145	151	159	152	152	141	153
1905	162	152	152	160	160	159	158	135	122	160	150	146
1906	177	172	184	187	185	184	180	184	182	181	187	183
1907	183	177	147	156	144	144	165	187	187	146	160	192
1908	192	190	158	129	110	146	182	183	186	179	191	188
1909	168	133	78	74	68	108	142	184	192	196	141	194
1910	182	176	139	93	68	119	149	180	179	178	177	164
1911	174	167	158	164	167	167	151	143	133	132	134	133
1912	136	136	136	135	131	130	134	163	165	171	180	177
1913	188	198	196	198	204	197	200	204	216	224	221	215
1914	223	222	218	209	209	214	216	220	256	271	276	297
1915	306	322	319	309	324	312	319	321	318	324	323	319
1916	317	317	339	366	379	474	429	485	512	505	492	493
1917	385	380	376	391	393	395	404	385	380	410	408	405
1918	432	426	439	428	401	437	454	478	459	480	470	457
1919	462	448	453	442	448	429	422	413	440	447	458	450

COORDINATING COMMITTEE ON GREAT LAKES
BASIC HYDRAULIC AND HYDROLOGIC DATA

LAKE SUPERIOR OUTFLOW 1860-1968

TABLE 5

TOTAL DIVERSION FOR POWER
IN HUNDREDS OF CUBIC FEET PER SECOND

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1920	464	461	455	455	470	468	465	463	469	475	480	455
1921	449	466	446	454	381	355	441	466	470	462	419	400
1922	390	418	423	419	381	373	394	399	392	428	440	441
1923	452	465	492	489	492	498	484	489	478	459	449	464
1924	477	478	492	491	496	465	428	468	453	458	477	473
1925	496	493	504	534	540	512	493	508	521	555	536	534
1926	525	517	506	510	530	520	509	358	234	234	224	329
1927	533	521	520	533	526	520	493	526	514	488	514	498
1928	522	536	524	532	531	508	465	478	496	551	604	535
1929	495	497	521	559	556	558	548	512	546	524	516	508
1930	504	498	526	520	485	465	468	489	508	502	492	466
1931	436	454	442	457	246	251	270	250	330	335	341	321
1932	471	531	544	465	357	299	349	358	391	345	333	317
1933	343	325	359	336	359	351	374	464	388	414	522	476
1934	517	542	552	538	511	523	528	540	545	542	553	554
1935	546	569	575	566	557	574	582	584	572	595	594	591
1936	595	598	595	589	569	583	564	581	582	595	597	595
1937	586	591	583	586	551	584	584	581	576	579	575	562
1938	559	558	540	532	465	617	700	681	684	676	486	543
1939	562	576	577	547	518	507	578	639	663	639	596	576
1940	588	596	512	501	525	527	565	579	567	572	571	574
1941	595	597	586	565	562	574	552	579	584	594	598	579
1942	581	577	582	550	561	561	548	564	587	592	545	585
1943	592	591	586	575	587	572	648	676	670	617	591	581
1944	575	571	568	565	581	576	554	565	564	586	590	578
1945	594	589	583	568	573	570	572	547	571	575	583	581
1946	579	594	578	312	314	576	568	582	583	601	581	589
1947	594	596	579	573	581	587	595	586	595	608	612	600
1948	598	599	596	588	604	608	601	593	549	557	555	553
1949	556	558	554	552	551	552	526	462	430	567	593	591

COORDINATING COMMITTEE ON GREAT LAKES
BASIC HYDRAULIC AND HYDROLOGIC DATA

LAKE SUPERIOR OUTFLOW 1860-1968

TABLE 5

TOTAL DIVERSION FOR POWER
IN HUNDREDS OF CUBIC FEET PER SECOND

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1950	565	602	602	597	603	603	639	652	656	647	646	599
1951	606	609	600	608	660	659	645	638	640	632	629	622
1952	636	627	623	607	615	618	617	632	627	632	624	617
1953	626	614	600	598	611	624	630	639	640	636	638	637
1954	633	623	617	607	626	635	578	638	634	633	642	599
1955	589	589	587	563	611	629	611	611	367	398	643	641
1956	634	638	636	625	634	571	583	640	636	655	653	654
1957	643	631	547	534	474	494	492	493	483	546	588	588
1958	655	649	632	551	550	544	515	519	524	595	620	602
1959	611	618	604	645	650	640	627	622	599	656	667	651
1960	641	660	636	588	551	630	637	625	636	641	607	628
1961	627	642	633	630	628	626	601	526	632	545	615	622
1962	618	629	616	601	563	559	593	567	527	570	622	612
1963	599	620	579	538	576	574	587	580	606	526	531	490
1964	542	626	636	624	633	645	631	666	664	676	682	682
1965	669	666	657	643	669	668	669	669	649	649	659	666
1966	663	662	670	658	673	660	658	668	663	685	685	674
1967	662	667	663	656	672	678	667	677	670	674	680	664
1968	664	667	648	659	665	662	657	670	677	653	665	671

COORDINATING COMMITTEE ON GREAT LAKES
BASIC HYDRAULIC AND HYDROLOGIC DATA

LAKE SUPERIOR OUTFLOW 1860-1968

TABLE 6

MEAN MONTHLY LAKE SUPERIOR OUTFLOWS
IN THOUSANDS OF CUBIC FEET PER SECOND

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	MEAN
1860	66	66	71	73	82	86	88	87	86	87	83	78	79
1861	67	66	66	66	84	89	93	90	91	89	86	79	80
1862	73	65	63	62	74	76	77	81	82	82	78	74	74
1863	66	63	60	58	63	64	67	71	74	74	76	70	67
1864	61	59	56	55	65	66	68	70	71	68	63	64	64
1865	56	50	50	57	71	77	82	82	81	80	71	67	69
1866	54	48	51	59	67	72	75	77	77	78	76	66	67
1867	57	61	63	64	74	72	80	83	82	77	73	68	71
1868	61	51	60	67	67	70	75	76	77	72	74	74	69
1869	61	57	50	59	70	71	81	90	99	98	90	73	75
1870	65	61	61	63	70	85	88	88	91	88	86	81	77
1871	73	70	65	67	79	87	91	89	90	86	81	73	79
1872	69	67	62	62	79	83	91	98	99	96	93	83	82
1873	75	72	73	73	84	87	96	102	103	100	95	91	88
1874	79	76	74	71	80	88	97	98	97	100	95	93	87
1875	84	79	78	83	89	96	98	98	104	101	95	83	91
1876	82	81	76	77	92	105	115	116	117	110	103	93	97
1877	86	87	85	82	82	87	94	96	91	92	87	84	88
1878	79	74	72	72	77	82	85	84	78	80	78	74	78
1879	67	59	55	57	64	66	72	73	71	72	68	61	65
1880	57	57	55	55	69	84	89	86	90	85	86	80	74
1881	74	72	72	70	78	83	87	86	89	99	97	90	83
1882	79	75	73	73	80	82	89	91	90	88	87	81	82
1883	73	71	71	72	72	79	83	92	85	82	79	74	78
1884	72	69	67	64	71	73	77	78	79	81	82	78	74
1885	75	72	70	66	78	84	88	92	87	84	82	77	80
1886	70	67	67	67	74	78	81	84	81	82	78	73	75
1887	69	66	66	63	70	77	84	82	79	82	77	70	74
1888	66	60	60	59	70	85	87	87	86	85	81	75	75
1889	70	65	65	65	75	78	83	84	83	80	75	68	74

COORDINATING COMMITTEE ON GREAT LAKES
BASIC HYDRAULIC AND HYDROLOGIC DATA

LAKE SUPERIOR OUTFLOW 1860-1968

TABLE 6

MEAN MONTHLY LAKE SUPERIOR OUTFLOWS
IN THOUSANDS OF CUBIC FEET PER SECOND

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	MEAN
1890	69	59	59	58	65	76	83	81	79	78	75	70	71
1891	58	60	57	61	67	66	68	68	67	68	66	63	64
1892	61	55	52	54	62	67	69	69	69	67	62	57	62
1893	55	52	52	56	63	71	74	76	74	73	72	64	65
1894	62	60	59	64	78	82	84	84	82	83	81	77	75
1895	73	71	68	68	72	78	82	82	85	87	79	77	77
1896	70	70	66	68	78	85	87	87	86	80	81	77	78
1897	74	69	69	70	77	83	88	89	87	84	83	75	79
1898	67	63	61	63	69	76	80	82	82	81	79	78	73
1899	69	67	67	65	81	87	91	93	97	92	89	86	82
1900	79	77	73	73	77	78	82	86	92	94	94	84	82
1901	80	75	69	70	76	79	86	86	81	81	78	72	78
1902	66	62	57	61	65	69	74	75	77	74	75	69	69
1903	64	61	60	62	70	77	79	81	80	81	80	73	72
1904	72	68	68	70	76	82	84	86	87	90	87	81	79
1905	78	71	67	74	79	82	87	87	89	93	88	84	82
1906	82	76	74	76	81	86	88	89	88	86	84	79	82
1907	74	71	67	70	72	78	83	88	91	87	85	82	79
1908	75	70	65	62	67	78	86	88	85	82	79	74	76
1909	67	61	54	53	56	63	69	76	76	76	69	74	66
1910	67	63	57	55	57	64	66	70	69	68	66	58	63
1911	55	50	47	48	52	56	58	63	62	62	60	58	56
1912	57	54	53	54	60	64	64	69	70	71	69	65	62
1913	62	60	58	61	68	70	73	75	76	79	78	75	70
1914	70	69	65	64	70	73	75	76	80	87	85	69	74
1915	67	67	66	64	70	71	75	76	75	75	76	73	71
1916	71	70	69	74	83	98	98	104	115	119	114	108	94
1917	89	86	84	88	90	91	89	80	83	85	82	65	84
1918	66	64	65	64	66	72	62	66	74	76	70	58	67
1919	58	56	56	56	58	56	57	55	59	58	59	59	57

COORDINATING COMMITTEE ON GREAT LAKES
BASIC HYDRAULIC AND HYDROLOGIC DATA

LAKE SUPERIOR OUTFLOW 1860-1968

TABLE 6

MEAN MONTHLY LAKE SUPERIOR OUTFLOWS
IN THOUSANDS OF CUBIC FEET PER SECOND

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	MEAN
1920	60	59	58	58	82	85	89	99	86	68	61	58	72
1921	56	57	54	56	51	49	58	61	61	60	51	48	55
1922	44	45	46	46	47	43	45	47	46	49	51	51	47
1923	50	51	54	53	60	56	55	55	54	53	52	53	54
1924	54	53	54	56	56	53	49	53	52	52	54	53	53
1925	55	54	55	59	60	55	53	59	74	77	74	68	62
1926	59	57	56	58	60	57	56	45	42	44	49	59	54
1927	72	72	71	74	76	78	76	81	79	77	82	75	76
1928	75	75	73	77	79	74	69	83	101	111	117	103	86
1929	69	55	61	101	98	76	91	76	74	60	58	56	73
1930	55	55	58	57	58	61	77	92	81	59	56	52	63
1931	49	51	49	51	44	46	49	47	55	56	57	53	51
1932	53	58	58	57	57	55	60	61	79	72	69	55	61
1933	49	47	50	48	53	56	69	65	61	65	75	54	58
1934	58	60	61	59	58	73	94	101	92	78	85	98	76
1935	70	62	76	96	99	89	94	95	99	110	104	68	88
1936	65	65	65	65	83	87	85	86	84	77	77	66	75
1937	64	64	64	65	62	76	72	72	73	73	72	64	68
1938	62	62	60	60	81	117	126	124	122	118	97	61	91
1939	62	63	63	74	101	104	116	126	124	112	76	66	91
1940	64	65	54	53	56	57	61	62	61	61	61	60	60
1941	62	62	61	60	60	60	57	60	61	77	108	84	68
1942	83	67	59	89	67	81	92	79	79	69	56	59	73
1943	60	64	75	81	90	110	123	127	125	114	99	75	95
1944	68	58	58	59	61	61	80	100	109	115	102	83	80
1945	75	74	74	86	108	106	76	74	73	81	94	75	83
1946	74	74	73	68	77	77	77	75	77	79	77	76	75
1947	75	75	73	73	76	78	117	115	102	114	91	78	89
1948	76	75	74	75	74	69	65	63	58	59	59	57	67
1949	57	57	57	59	63	63	61	66	72	72	72	67	64

COORDINATING COMMITTEE ON GREAT LAKES
BASIC HYDRAULIC AND HYDROLOGIC DATA

LAKE SUPERIOR OUTFLOW 1860-1968

TABLE 6

MEAN MONTHLY LAKE SUPERIOR OUTFLOWS
IN THOUSANDS OF CUBIC FEET PER SECOND

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	MEAN
1950	63	66	66	66	69	105	124	127	126	124	121	113	98
1951	82	80	80	104	122	123	124	123	124	124	121	103	109
1952	84	82	81	82	107	79	67	117	117	114	107	75	93
1953	74	72	70	78	93	98	107	120	119	114	101	80	94
1954	74	72	72	71	76	77	100	116	113	96	76	65	84
1955	62	62	61	60	72	75	70	66	41	50	83	77	65
1956	74	74	73	76	69	61	62	72	72	73	70	69	70
1957	67	66	57	57	52	54	54	64	67	67	66	65	61
1958	71	71	69	61	62	62	57	56	57	66	69	66	64
1959	66	67	65	70	70	69	67	69	75	112	118	89	78
1960	74	72	69	66	68	111	115	105	103	92	73	68	85
1961	67	67	66	66	68	69	65	57	57	58	65	65	64
1962	64	65	64	63	60	60	63	61	56	64	68	65	63
1963	63	65	60	57	61	61	63	62	72	64	67	56	63
1964	59	67	68	68	70	72	81	100	107	111	116	93	84
1965	86	84	83	82	94	99	113	114	108	102	102	85	96
1966	77	77	77	81	80	79	96	96	104	91	80	75	84
1967	71	72	71	71	85	90	90	92	87	71	72	70	78
1968	69	69	67	69	70	70	100	122	123	124	123	105	93